

What is claimed is:

CLAIMS

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1. ~~An actuator for providing vibration forces in a haptic feedback device, the actuator comprising:~~

a core member, said core member being grounded to a ground member;

a coil wrapped around a central projection of said core member;

a magnet head positioned so as to provide a gap between said core member and said magnet head, wherein said magnet head is moved in a degree of freedom based on an electromagnetic force caused by a current flowed through said coil; and

an elastic material positioned in said gap between said magnet head and said core member, wherein said elastic material is compressed and sheared when said magnet head moves and substantially prevents movement of said magnet head past a range limit, said range limit based on an amount to which said elastic material may be compressed and sheared.

2. An actuator as recited in claim 1 wherein said elastic material is foam.

3. An actuator as recited in claim 1 wherein said actuator is driven by a drive signal that causes said magnet head to oscillate and produce a vibration in said ground member.

4. An actuator as recited in claim 1 further comprising at least one flexible member coupled between said magnet head and said ground member, said flexible member flexing to allow said magnet head to move in said degree of freedom.

5. An actuator as recited in claim 4 wherein said at least one flexible member is coupled between said magnet head and a ground surface to which said core member is coupled.

6. An actuator as recited in claim 4 wherein said at least one flexible member is coupled between said magnet head and a ground surface to a side of said core member.

7. An actuator as recited in claim 4 wherein at least one flexible member is coupled to a housing of said actuator.

8. An actuator as recited in claim 1 wherein said degree of freedom of said magnet head is linear.

9. ~~An actuator as recited in claim 1 wherein said degree of freedom of said magnet head is rotary, where said magnet head moves in a rotary path.~~

10. An actuator as recited in claim 9 wherein said core member and said magnet head include curved surfaces to form a curved gap, wherein said elastic material is positioned in said curved gap.

11. An actuator for providing vibration forces in a force feedback device, the actuator comprising:

a core member, said core member being grounded to a ground member;

a coil wrapped around a central projection of said core member;

a magnet head positioned adjacent to said core member, wherein said magnet head is moved in a degree of freedom based on an electromagnetic force caused by a current flowed through said coil; and

at least one flexible member coupled between said magnet head and said ground member, said at least one flexible member flexing to allow said magnet head to move in said degree of freedom and providing a centering spring force to said magnet head, and wherein said at least one flexible member limits said motion of said magnet head such that said magnet head does not impact a hard surface.

12. An actuator as recited in claim 11 further comprising an elastic material positioned in a gap provided between said magnet head and said core member, wherein said elastic material is compressed and sheared when said magnet head moves and substantially prevents movement of said magnet head past a range limit provided by said elastic material.

13. ~~An actuator as recited in claim 11 wherein said at least one flexible member is coupled between said magnet head and a ground surface to which said core member is coupled.~~

14. An actuator as recited in claim 11 wherein said at least one flexible member is coupled between said magnet head and a ground surface to a side of said core member.

15. ~~An actuator as recited in claim 11 wherein at least one flexible member is coupled to a housing of said actuator.~~

16. An actuator as recited in claim 11 wherein ~~said degree of freedom of said magnet head is linear.~~

17. An actuator as recited in claim 11 wherein ~~said degree of freedom of said magnet head is rotary,~~ where said magnet head moves in a rotary path.

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18. A haptic feedback device coupled to a host computer, said host computer displaying a graphical environment, said haptic feedback device comprising:

a user manipulandum physically contacted by a user and moveable in at least one degree of freedom;

10 at least one sensor that detects a position of said user manipulandum in said at least one degree of freedom and provides a sensor signal to said host computer, said sensor signal including information representative of said position; and

15 an actuator coupled to said haptic feedback device which outputs a vibration force transmitted to said user, said force correlated with an event or interaction within said graphical environment, wherein said actuator includes:

a core member, said core member being grounded to a ground member;

a coil wrapped around a central projection of said core member;

20 a magnet head positioned so as to provide a gap between said core member and said magnet head, wherein said magnet head is moved in a degree of freedom based on an electromagnetic force caused by a current flowed through said coil; and

25 an elastic material positioned in said gap between said magnet head and said core member, wherein said elastic material is compressed and sheared when said magnet head moves and substantially prevents movement of said magnet head past a range limit, said range limit based on an amount to which said elastic material may be compressed and sheared.

19. A haptic feedback device as recited in claim 18 wherein said actuator is coupled to a housing of said haptic feedback device such that said vibration force is transmitted to said user through said housing.

20. A haptic feedback device as recited in claim 18 wherein said degree of freedom is a linear degree of freedom, and wherein said magnet head is oscillated in said linear degree of freedom to provide said vibration force.

5 21. A haptic feedback device as recited in claim 18 wherein said degree of freedom is a rotary degree of freedom, and wherein said magnet head is oscillated in said rotary degree of freedom to provide said vibration force.

10 22. A haptic feedback device as recited in claim 18 further comprising at least one flexible member coupled between said magnet head and a ground member of said haptic feedback device, said flexible member flexing to allow said magnet head to move in said degree of freedom.

23. A haptic feedback device as recited in claim 18 wherein said haptic feedback device is a gamepad controller and said user manipulandum is a joystick moveable in two degrees of freedom.